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(71) Applicant(s)
Norweb Plc
(Incorporated in the United Kingdom)
Talbot Road, MANCHESTER, M16 0HQ,
United Kingdom

(72) Inventor(s)
Paul Anthony Brown
John Dickinson

(74) Agent and/or Address for Service
Mewburn Ellis
York House, 23 Kingsway, LONDON, WC2B 6HP,
United Kingdom

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None

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(54) Abstract Title
Coupling telecommunications signal to power cables

(57) The present invention provides a method of coupling a telecommunications signal to a plurality of power cables (15), each cable being connected in a line to a bus-bar (11-13) the method including the steps of selecting one of the cables located substantially in the centre of the line and either coupling the telecommunications signal to the selected cable or coupling the signal to the bus-bar in the vicinity of the selected cable. By "in the vicinity" is preferably meant at or near the selected cable e.g. nearer to the selected cable than to any of the other cables connected to the bus-bar. Where a telecommunications signal is to be connected to a plurality of power cables, one aim is usually to ensure a roughly equal distribution of telecommunications signal power among the power cables. By making the physical connection in the vicinity of one of the central cables in the line, as proposed above, this helps to ensure that the signal power is approximately distributed in as equal away as possible. A fuse holder modified to include a telecommunications signal connector is also disclosed (figs. 2-5 not shown).

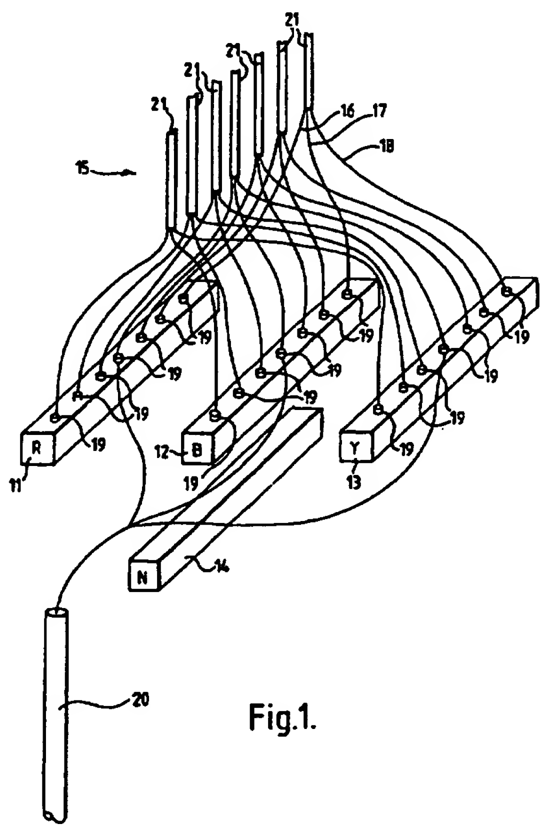

Fig.1.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

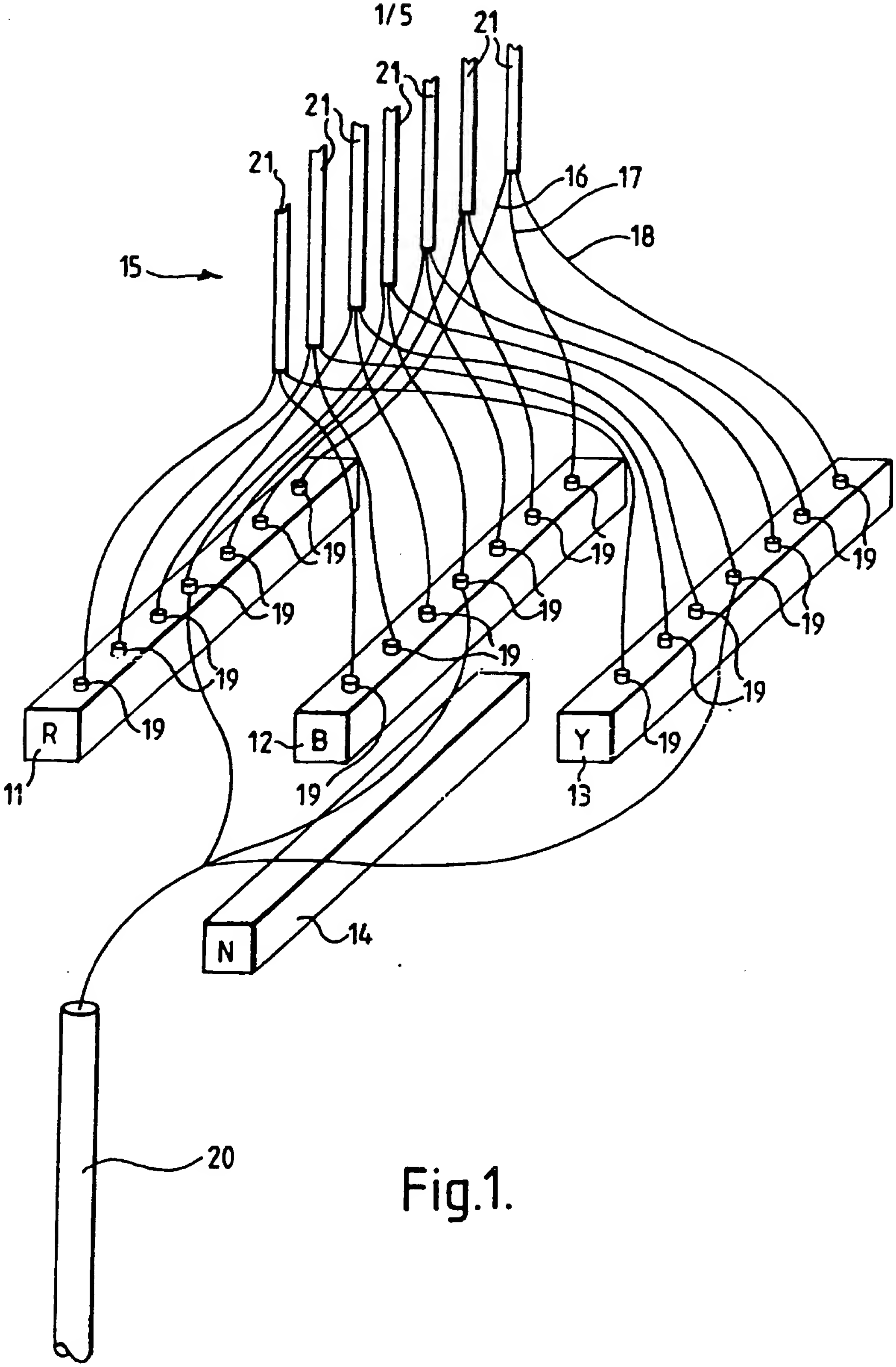


Fig.1.

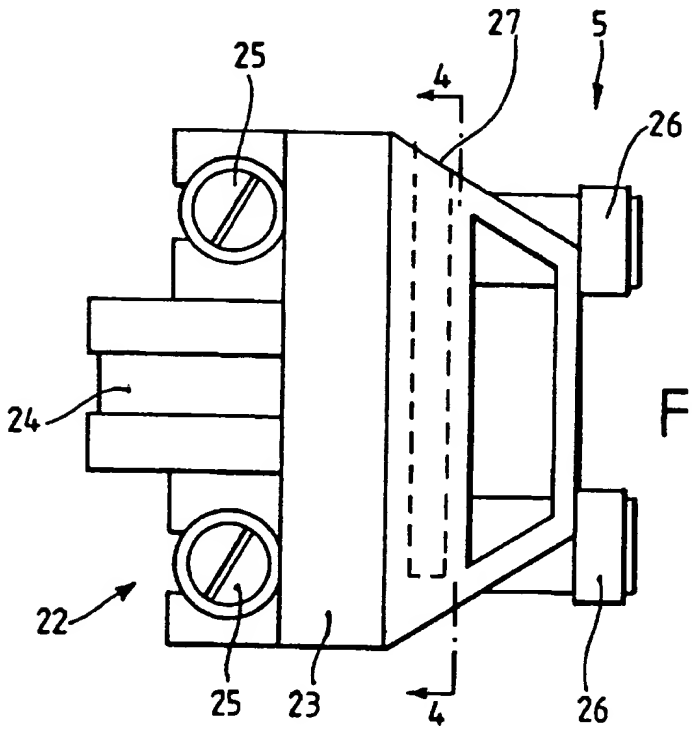
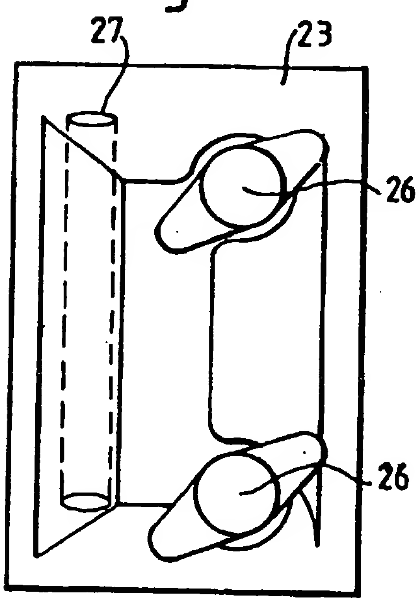


Fig.2.

Fig.3.



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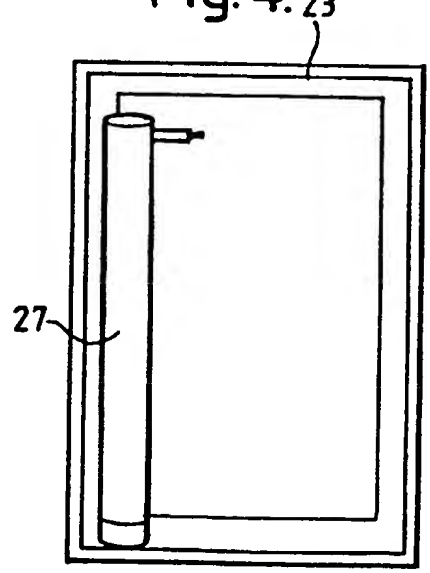

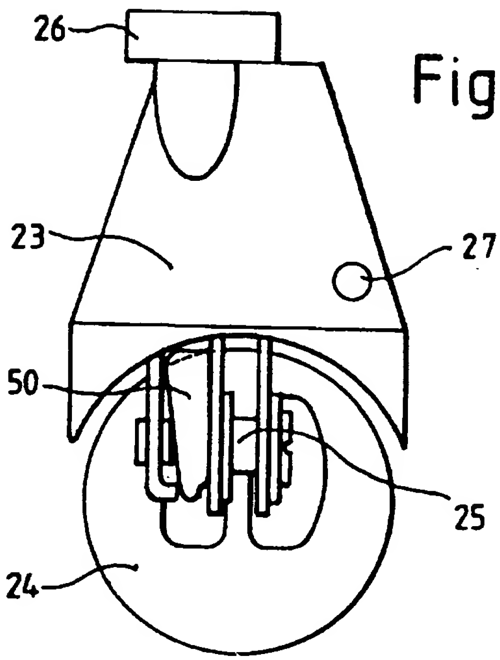

Fig.5.

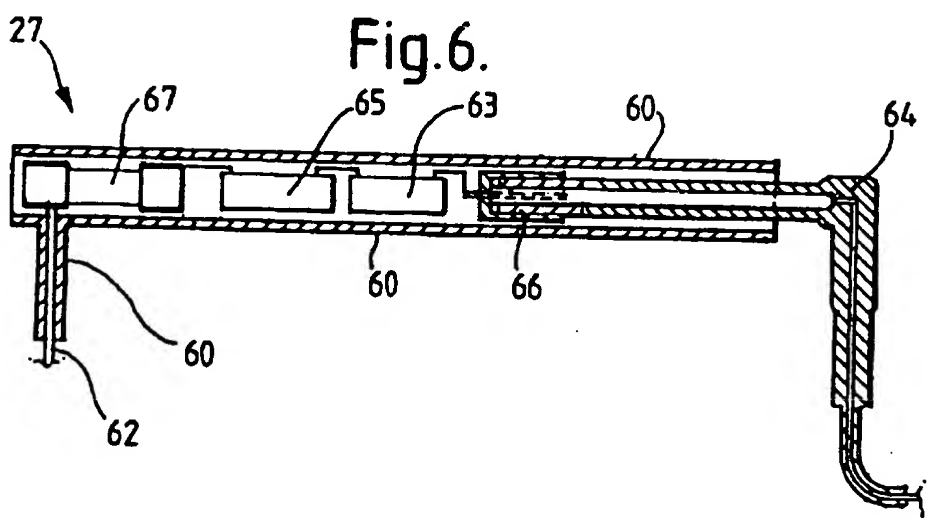

Fig.6.

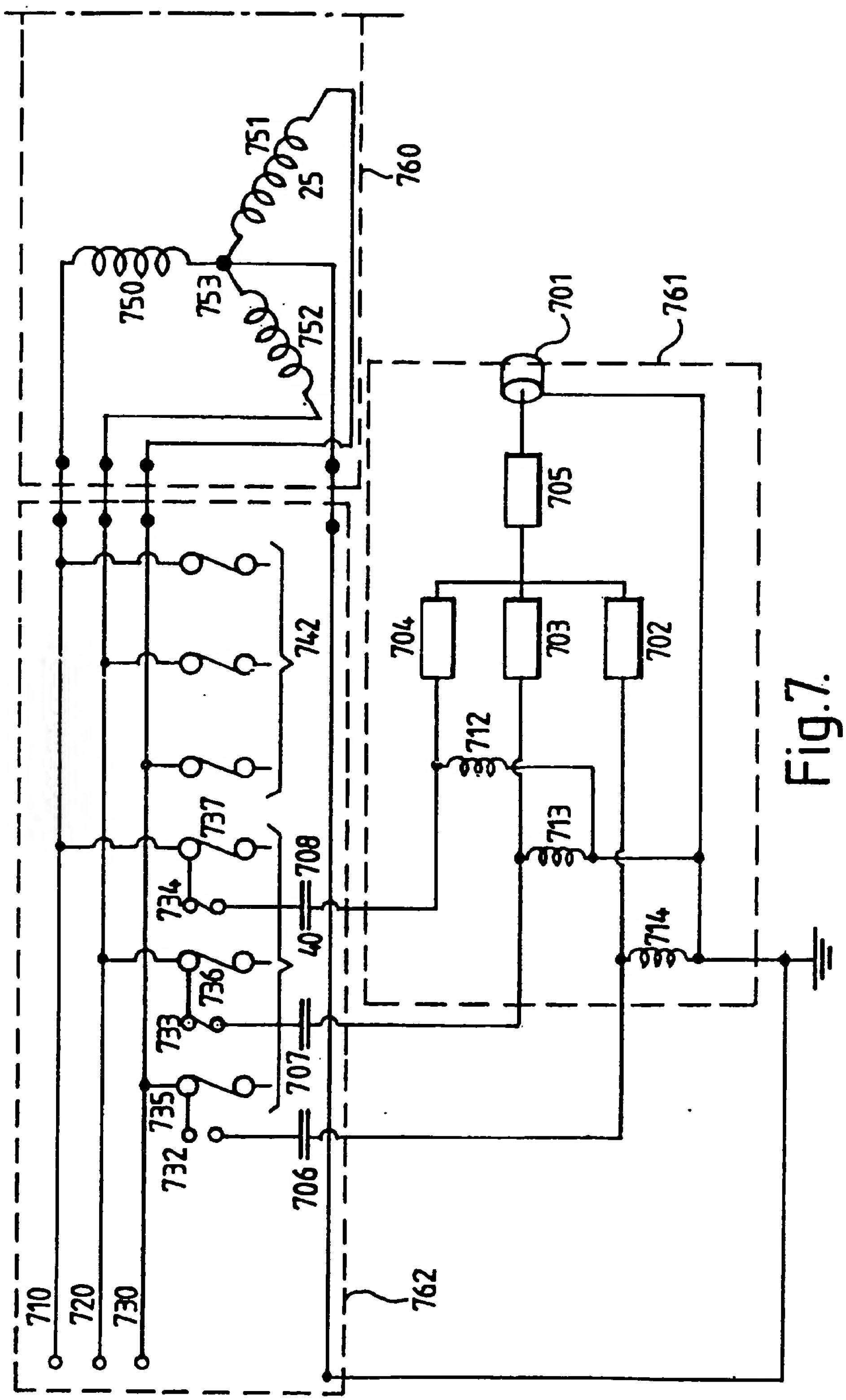

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Fig.7.

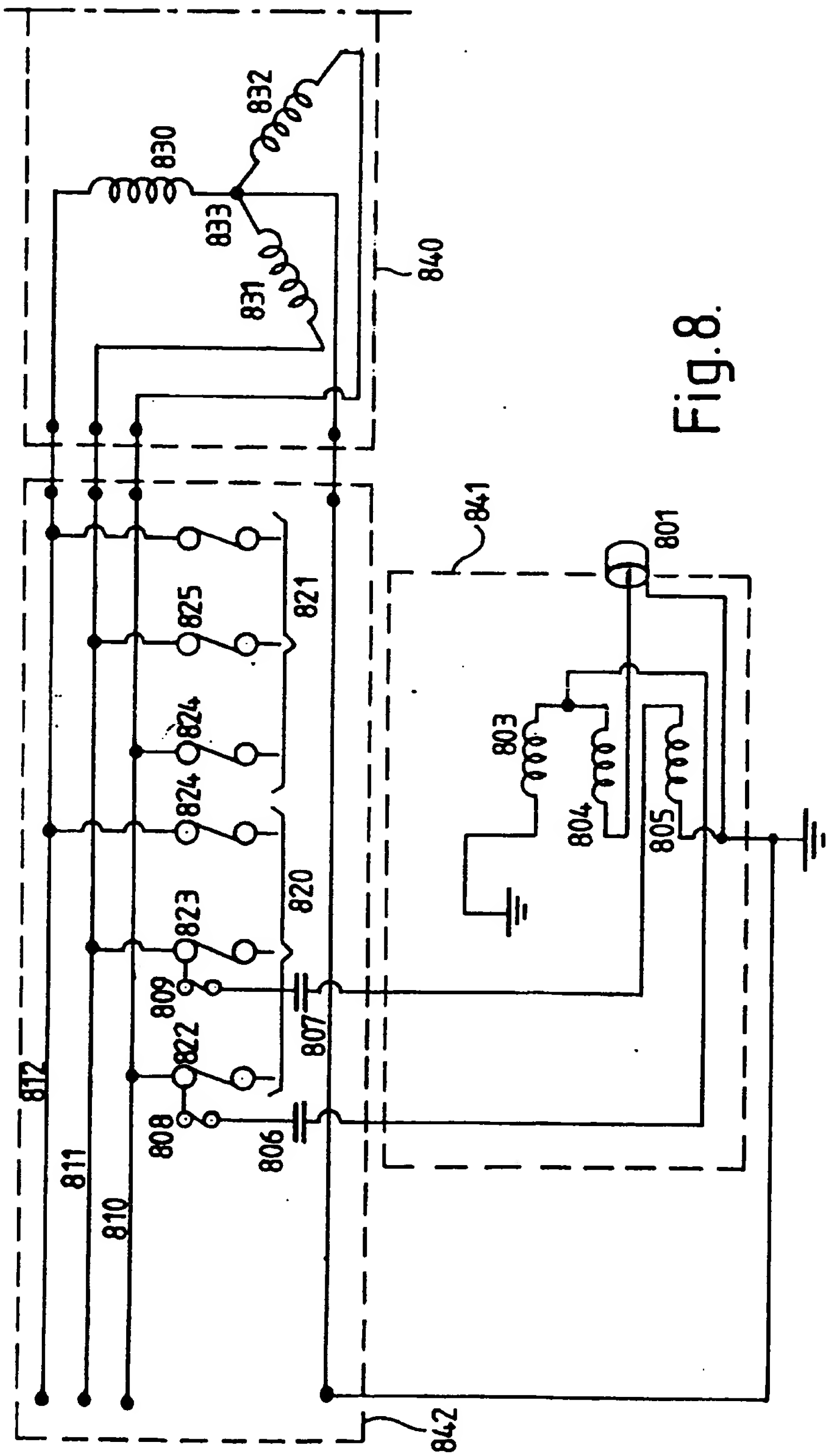
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Fig.8.

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CONNECTOR AND METHOD OF CONNECTION

The present application relates to an electrical connector and to a method of connection. In particular it relates to an electrical connector for connecting high frequency telecommunications signals on to an electricity transmission or distribution network.

Such connectors may be required for use with mains electricity distribution and/or transmission networks (generally referred to herein as power networks). In particular, such connectors are useful in order to safely connect high frequency signals from a telecommunications network on to a power network for powerline telecommunications applications. Such powerline telecommunications systems are described in the applicant's co-pending published International patent applications, numbers PCT/GB95/02023, PCT/GB95/00894, PCT/GB95/00893, PCT/GB95/02163 and PCT/GB97/02937. The teaching and disclosures of these five patent applications should be referred to in relation to the present invention and are incorporated herein by reference.

As it is now becoming more desirable to connect telecommunications networks to power networks so that telecommunication signals can be transmitted along those power networks, it becomes important to find suitable methods for making such connections and suitable apparatus for doing so. The power network

environment is a particularly hostile environment for telecommunications signals and for work generally, due to the high voltages and currents typically involved. The equipment which may be used on such power networks is therefore usually highly regulated and strictly controlled; these considerations should be taken into account when determining how to connect to the power network.

Particular problems arise when attempting to connect telecommunications signals to a power network at or near a distribution transformer point on the power network. At a distribution transformer point, typically, a number of polyphase electrical distribution feeder cables are interconnected via fuse links and bus-bar sections to a transformer secondary and/or primary winding. However, given that such distribution transformer points are usually (a) above ground and (b) therefore accessible, these can typically be some of the more convenient points at which to access the power network for telecommunications purposes.

The present invention aims to provide a method of connecting a telecommunications network on to a power network at or near such a bus-bar section, and also aims to provide apparatus suitable for making a connection.

Accordingly, in a first aspect, the present invention

provides a method of coupling a telecommunications signal to a plurality of power cables, each cable being connected in a line to a bus-bar, the method including the steps of selecting one of the cables located substantially in the centre of the line and either coupling the telecommunications signal to the selected cable or coupling the signal to the bus-bar in the vicinity of the selected cable. By "in the vicinity" is preferably meant at or near the selected cable e.g. nearer to the selected cable than to any of the other cables connected to the bus-bar.

Where a telecommunications signal is to be connected to a plurality of power cables, one aim is usually to ensure a roughly equal distribution of telecommunications signal power among the power cables. By making the physical connection in the vicinity of one of the central cables in the line, as proposed above, this helps to ensure that the signal power is approximately distributed in as equal away as possible.

Preferably, the telecoms signals have a carrier frequency of at least 1 MHZ.

While a single phase application is possible, typically the power cables in question will be polyphase power cables (e.g. containing 2, 3, 4 or more phases) and there will therefore be a plurality of bus-bars with one bus-bar for each phase, plus probably a neutral bus-bar. Clearly the respective phases of each cable

will each be connected to a respective bus-bar of the appropriate phase. As an example, if each cable is a three phase cable (e.g. red, yellow and blue phases), then there will be three live bus-bars (red, yellow and blue phases) and each yellow phase of each cable will be connected to the yellow phase bus-bar, each blue phase of each cable to the blue phase bus-bar etc. In such a case, the telecommunications signal will preferably be coupled to each of the bus-bars in the vicinity of the connections of the respective phases of the selected cable. The telecommunications signal may be coupled to as many or as few of the available phases/conductors as desired in eg balanced-balanced, balanced-unbalanced or unbalanced-unbalanced or unbalanced-balanced modes.

If there are an odd number of cables arranged in, for example, a line then the selected cable will preferably be the centre cable in the line. However, if there are an even number of cables in the line then the selected cable may be one of the two centre cables in the line or possibly the coupling may be made at a point e.g. substantially centrally between the two centre cables in the line. If the arrangement is other than in a line then the decision of where to make the physical coupling will be based on which location is likely to provide the most even telecommunications signal power distribution to the power cables - which is of course the same consideration as applies when the power cables are in a line.

As mentioned above, each electricity distribution feeder cable (and indeed each phase of each cable) may be connected to the respective bus-bars by separate fuse links. Such fuse links, or fuse holders, are generally relatively easily removable from a system in order that the fuses can be replaced when necessary. However the fuse links are usually of an approved design and so substantial modifications to that design might necessitate further approval.

Accordingly, in a second aspect, the present invention provide a fuse holder for use in a power network, the holder including means for holding a fuse element, means for connecting the fuse element to the power network, and means for coupling a telecommunications signal to the power network.

By incorporating means for coupling a telecommunications signal to the power network in to the fuse holder, a simple coupling mechanism is provided which is relatively easy to retro-fit to existing power networks.

Preferably, the fuse holder is of a standard approved type, for example containing a fuse link held in place by one or more clamps and also incorporating one or more fixing means for fixing the fuse holder in place on a bus-bar once the fuse holder has been inserted into or onto the bus-bar. Preferably the means for coupling the telecommunications signal to the power

network includes at least one capacitive coupler (e.g. a capacitor) and a connector means by which a telecommunications signal cable can be connected to the means for coupling. The means for coupling may also include an in-line fuse.

This second aspect of the present invention may be used in connection with the first aspect of the present invention or alternatively may be used in systems where the first aspect of the present invention is not used and/or appropriate.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a schematic view of a typical distribution cable and bus-bar connection arrangement, showing how a telecommunications signal may be coupled to the arrangement according to the present invention.

Figure 2 is a side view of an embodiment of a fuse holder according to the present invention.

Figure 3 is a top view of the embodiment of figure 2 along the line of arrow 3.

Figure 4 is a cross sectional view along the line 4-4 of figure 2.

Figure 5 is a side view of the embodiment of figure 2 in the direction of arrow 5.

Figure 6 is a schematic view of the coupling means included in the embodiment of figure 2.

Figure 7 is a schematic diagram of a polyphase to earth RF signal interface configuration according to an embodiment of the present invention.

Figure 8 is a schematic diagram of a phase to phase RF signal interface configuration according to an embodiment of the present invention.

Figure 1 shows a system of connections between a plurality (in this case 7) distribution cables 15 and a bus-bar system. In this case the bus-bar system consists of four bus-bars 11-14; these are three live phase bus-bars 11-13 (red, blue and yellow phases respectively) and a neutral bus-bar 14. For simplicity, no connections to the neutral bus-bar have been shown although in practice each distribution cable would usually have a further connection to the neutral bus-bar.

Each distribution cable is a polyphase cable, in this case including three phases each of which is on a separate conductor 16, 17, 18. The respective phase conductors of each distribution cable are each connected to the appropriate bus-bars i.e. the red

phase conductor 16 of the first distribution cable is connected to the red phase bus-bar 11 and so on. The seven distribution cables 15 are arranged in a straight line and their respective connections to the bus-bars 11-13 are similarly in straight lines. Each distribution cable phase conductor is connected to an appropriate bus-bar via a fuse holder 19.

According to the present invention, it is desired to make a connection between a telecommunications signal carrying conductor 20 and each of the seven distribution cables. This is done by selecting the central distribution cable 21 in the line of distribution cables and making the connection between the telecommunications signal and the bus-bars either to cable 21 or to the bus-bars in the vicinity of the connection between cable 21 and the bus-bars. In the example shown, the connection between the telecommunications signal is made to each phase conductor of distribution cable 21 at the fuse holder 19 which connects those phase conductors to their respective bus-bars. In this way the signal power of the telecommunications signal 20 is distributed reasonably evenly between the seven distribution cables 15.

Figure 2 shows a fuse holder (generally indicated 22) according to an aspect of the present invention. The fuse holder 22 consists of a main body moulding 23 which carries a fuse link 24 held in place by a pair of

bolt clamps 25 and carrier assemblies 50 (better seen in figure 5). When the fuse carrier is located in place in or on a bus-bar socket (usually after having been pushed home e.g. by hand), the fuse holder is held in place by insulated thumb screws 26, which are usually rotated clockwise to secure the fuse holder in place.

The fuse holder shown in figure 2 is modified from a standard fuse holder by the inclusion of a telecommunications signal connector, shown generally as 27. This will be described in more detail with reference to figure 6.

Figures 3-5 show other views of the fuse holder 22, as explained above.

Figure 6 shows in more detail the telecommunications signal connector 27 which is inserted into the slot in the fuse holder 22, shown by a dashed line in figure 2. The connector 27 consists of an insulated body 60 inside which are contained various connector components. Electrical connection is made from the connector components to the fuse link 24 or holder 25 via a lead 62 which extends out of the insulated body 60. A detachable RF connection is made to the device via a safety probe 64 which connects to a socket 66. The RF signals are then capacitively coupled via one or more capacitors (63, 65) and an optional fuse 67 to the connector 62. The value of the coupling capacitor(s)

is chosen and their safe working voltage(s) is dependent upon the RF signal frequency(ies) and the bus-bar phase to phase and/or phase to neutral and/or earth potentials at 50/60Hz (i.e. the relatively high amplitude power components) respectively.

The RF signal should be fed, via the modified fuse links, onto the necessary phase conductors, if appropriate with respect to neutral and/or earth, of the network with the necessary safety earth(s), matching devices (i.e. balanced to unbalanced, unbalanced to balanced, polyphase to neutral earth etc) and over voltage and/or surge protection devices.

Figure 7 illustrates a polyphase to earth RF signal interface configuration. The RF communication signals are interfaced via the unbalanced coaxial port 701 via the resistive splitter/combiner network consisting of resistors 702-705 each of which feed a portion of the RF signals via the coupling capacitors 706-708 onto each of the 3 bus-bars 710, 720 and 730 via fuse links 732-734 respectively. Also the RF signals propagate via the main fuse links 735-737 onto the polyphase cable 740 which is assumed to be of a clad type with a neutral earth sheath. Cable 742, which is another distribution cable, is also assumed to be of a similar type.

The RF chokes (inductors) 712-714 provide a low impedance path at 50/60 Hz (i.e. at power frequencies)

should capacitors 705-708 become short circuit thus enabling fuse links 732-734 to fail to safety. However the chokes 712-714 are constructed such that they have a relatively high impedance with respect to the RF communication signals and therefore do not attenuate these signals.

The power transformer secondary windings 750-752 are shown for clarity and the neutral or star point 753 is earthed in this configuration. Each of the three major component assemblies 760-762 may be separately housed if required for safety reasons. Components 706-708 and 732-734 are incorporated in their respective main fuse link housings, 735-737 as detailed in figure 2.

Figure 8 illustrates a phase to phase RF signal interface configuration. The RF communication signals are interfaced via the unbalanced coaxial port 801, the balun transformer (consisting of windings 803-805 which might typically be wound on a ferrite ring core), capacitors 806, 807 and fuse links 808, 809 onto bus-bars 810, 811.

Balun transformer windings 803 and 805 provide low impedance paths to earth at 50/60 Hz should capacitors 806 and/or 807 fail to short circuit and thereby enable fuse links 808 and/or 809 to fail to safety. The balun transformer windings 803-805 maintain a relatively high impedance with respect to the RF communication signals and therefore do not attenuate these signals.

The RF communication signals applied to bus-bars 810 and 811 are similarly linked to cable 820 via the main fuse links 822 and 823 and similarly onto cable 821 via main fuse links 824 and 825. The power transformer secondary windings 830-832 are shown for clarity and the neutral or star point 833 is earthed in this configuration. Each of the three major component assemblies 840, 841, 842 may be separately housed if required for safety reasons. Components 806, 807 and 808, 809 are incorporated in their respective main fuse link housings 822 and 823 as detailed in figure 2.

The above embodiments of the present invention have been described by way of example only and various alternative features or modifications from what has been described can be made within the scope of the invention, as will be readily apparent to persons skilled in the art.

CLAIMS

1. A method of coupling a telecommunications signal to a plurality of power cables, each cable being connected in a line with the other cables to a bus-bar, the method including the steps of selecting one of the cables located substantially in the centre of the line and either coupling the telecommunications signal to the selected cable or coupling the signal to the bus-bar in the vicinity of the selected cable.

2. A method according to claim 1 wherein the telecommunication signal is coupled nearer to the selected cable than to any of the other cables connected to the bus-bar.

3. A method according to Claim 1 or Claim 2 wherein the telecom signal has a carrier frequency of at least 1 MHZ.

4. A method according to any one of the above claims wherein the power cables are polyphase power cables, there is one bus-bar for each phase, the telecommunication signal is coupled to each of the bus-bars in the vicinity

of the connections of the respective phases of the selected cable.

5. A method according to any one of the above claims wherein, when there are an odd number of cables arranged in a line, then the selected cable is the centre cable in the line.

6. A method according to any one of claims 1 - 4 wherein, when there are an even number of cables in the line, the selected cable is either one of the two centre cables in the line or the coupling is made at a point substantially centrally between the two centre cables in the line.

7. A method according to any one of the above claims wherein each power cable is connected to the respective bus-bars by respective separate fuse links, and the telecom signal is coupled via at least one fuse link.

8. A method according to claim 7 wherein the fuse link is as claimed in any one of claims 9 - 11 or 13.

9. A fuse holder for use in a power network, the holder including means for holding a fuse element, means for connecting the fuse element to the power network, and means for coupling a telecommunications signal to the power network.

10. A fuse holder according to claim 9 which includes a fuse link held in place by one or more clamps and also includes one or more fixing means for fixing the fuse holder in place on a bus-bar once the fuse holder has been inserted into or onto the bus-bar.

11. A fuse holder according to claim 9 or 10 wherein the means for coupling the telecommunications signal to the power network includes at least one capacitive coupler and a connector means by which a telecommunications signal cable is connectable to the means for coupling.

12. A method of coupling a telecoms signal substantially as any one embodiment herein described with reference to the accompanying drawings.

13. A fuse holder substantial as any one embodiment herein described with reference to the accompanying drawings.

The Patent Office

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INVESTOR IN PEOPLE

Application No:	GB 9825748.8	**Examiner:**	Mr.Sat Satkurunath
Claims searched:	1-8, 12	**Date of search:**	26 February 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4R: RTC, RTSU, RTT, RTR

Int Cl (Ed.6): H02J, H04B

Other: Online: WPI, JAPIO, EDOC

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	NONE	1-8, 12

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.